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WORD RECALL AND CLUSTERING AS A FUNCTION OF DELAY INTERVAL, LIST TYPE AND SORTING TECHNIQUE

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HUMAN ENGINEERING LABORATORIES

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ABSTRACT

The purpose of the experiment was to test the hypothesis that amount recalled and clustering, occurrence of related words in strings of two or more, are inversely related to the delayed recall interval.

The experimental manipulations employed were list type - categorized and random, card sorting technique - free or constrained, and delay interval - 1 hr., 2 hr., 5 hr., 24 hr., and one week. The results indicated that the amount recalled and number of clusters recalled decreased with increases in the delay interval. However, word frequency, degree of clustering and cluster size were not affected.

List type was found to be the most important determiner of performance. The categorized list group recalled more words, had the greatest degree of clustering and formed larger clusters than the random list group.

The card sorting task was a modification of Mandler and Pearlstone (1966). The free-sort group recalled more words and used more clusters than the constrained-sort group. The constrained-sort group formed larger clusters than the free-sort group. Sorting technique was not seen as a factor in determining the degree of clustering.

The results were interpreted as supporting Miller's (1956) coding hypothesis about superordinate and subordinate labels. The nature of the categorization was not found to be exclusively organizational or associational.

Implications for a theory of the storage and retrieval processes in memory were discussed with respect to the Tulving and Pearlstone (1966) concepts of availability and accessibility. Generally, forgetting was found to be a combination of changes that take place during storage and the lack of appropriate retrieval cues.

The experiment substantiated previous findings on the relationship of organization and recall. Mandler (1967) placed emphasis upon the relationship of categories to amount recalled while the present experiment showed the relationship to exist between the number of clusters and amount recalled.

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INTRODUCTION

In an early experiment concerned with the characteristics of associative responses, Bousfield and Sedgewick (1944) noticed that subjects (Ss) consecutively recalled certain list items. Given a list of animals presented in a random order, Ss would recall all of the canines in the list, then the felines, etc. Subsequent studies have indicated that following the presentation of a list of words immediate free recall is often characterized by the occurrence of such organization. This organization, called clustering, is the occurrence of "related" words in strings of two or more to an extent greater than would be predicted by chance (Bousfield, 1953; Bousfield and Cohen, 1953, 1955; Cohen and Bousfield, 1956). Generally, three explanations of the clustering phenomenon have been offered.

In their early series of experiments Bousfield (1953), Bousfield and Cohen (1953, 1955), Cohen and Bousfield (1956), relied heavily on Hebb's (1949) explanation of superordinate perceptions. As applied to the free recall situation

> the perception or recall of a single word will tend to activate the superordinate systems which correspond to the category represented by the word. Once this superordinate system is activated, it will tend to facilitate the perception and recall of other words belonging to the same category. (Schuell, 1969, p. 369)

Subsequent studies by these investigators (Bousfield and Bousfield, 1966; Bousfield and Puff, 1965; Bousfield, Stewart and Cowan, 1964) have tended to follow the line of reasoning of Deese (1959, 1962, 1968) and Cofer (1959) where emphasis is placed upon associative clustering rather than categorical clustering.

According to Schuell (1969) associative clustering

> refers to the situation in which the stimulus list is comprised of associatively related words (as determined from associative norms) which are not members of the same conceptual category. (p. 354)

An example of this type of clustering would be the consecutive recall of piano, note, song, sound (Deese, 1962) which were randomly presented in a longer list. Categorical clustering or coding refers to the situation in which "the stimulus list is comprised of words representing two or more

mutually exclusive conceptual categories" (Schuell, 1969, p. 354). An example of this type of clustering had been given previously regarding the recall of animal types.

The concept of coding (Miller, 1956) comes out of information theory and assumes a hierarchical arrangement of information. Words are grouped together to form categories, a label is attached and entered into memory. When there are enough of these labels (7 ± 2) that are similar they are given a superordinate label and it also enters memory. It was hypothesized then that recall of the superordinate label elicits recall of subordinate labels and subsequently, the individual words. This concept of categorization, also called the "unitization hypothesis", is adhered to by Mandler (1967), Tulving (1966), and Earhard (1967).

Both types of clustering have been shown to occur during free recall (Bousfield and Puff, 1965); however, they are assumed to occur at different levels of the task. Deese (1961) and Cofer (1967) maintain that associations occur during recall and are thus involved in the retrieval process, while Mandler (1967) and Tulving (1964) maintain that coding occurs during input directly affecting the storage of the material. Similarly Kendler (1966) states

> Tulving indicates that verbal material is organized and therefore recalled; Cofer in his analysis of clustering, suggests that items are retained and organized into conceptual categories during free recall because of their inter-word association. (p. 199)

In order to arrive at a quantification of the concept of clustering, Bousfield (1953) set up the ratio of repetition, RR = r/N-1, where N is the total number of words recalled. The words from a particular category that are recalled contiguously in runs of two or more (minus one because the first item recalled cannot be a repetition) summed over all runs in the list recalled becomes r. For example, in the series xxxxyxzyyyxyyzzz, RR = .56. RR = 1.00 only when one run is recalled. The basic assumption of this measure is that all items are equally available for recall. In a recent review Schuell (1969) compares and criticizes the major clustering indices and their assumptions while also providing intercorrelations between them and their relationship to the number of words recalled. No recommendations were offered.

The stimulus materials have generally been of two basic types. The first type consists of an experimenter (E) defined or structured list of associated words from a discrete number of superordinate categories. The second type of list is a random assortment of presumably unrelated words, that is no apparent inter-item associations. The persistence of chunking on the part of S was seen to occur with the organized list in a number of studies (Matthews, 1954; Dallett, 1964; Tulving and Pearlstone, 1966; Cofer, Bruce and Reicher, 1966; Gonzales and Cofer, 1959). Tulving (1962) found the occurrence of chunks or subjective units (S-units) during recall of apparently unrelated words. That is, where no obvious or efficient structure exists, S will impose his own order upon the list to establish an idiosyn-

cratic mnemonic. This effect was also found to be present in Cofer (1965), Mandler (1967) and Mandler and Pearlstone (1966).

Studies directly comparing clustering in categorized and random lists are rare. Earhard (1967) compared alphabetic organization with a variety of 24 item lists. The lists varied in the ratios of words to letters from 24 words, each beginning with a different letter to 12 words for each of two letters. Additional words per letter were 3, 4, 6 and 8. Her general finding was an inverse relationship between category size and performance. In other words, the random list had better recall. The reason suggested for this finding was the cues given to her Ss on the alphabetic structure of the list.

The appearance of the S-units is not limited to lists of unrelated words. Subjective organization has been shown to exist in all types of lists. However, as Cofer (1965) points out, the more obvious that E-defined categories are in a particular list, the less likely idiosyncratic S-defined clusters are to appear during recall.

Mandler and Pearlstone (1966) and Mandler (1967) employed the use of the card-sort technique to investigate clustering. S's task was to sort words, which were typed on cards, into superordinate categories. The sorting technique was utilized in order that S might provide E with some insight into the optimal strategy used to organize the words.

Mandler and Pearlstone (1966) used two distinct sorting groups in their experiment. Ss in the first group (free) were permitted to choose the number of piles, 2 through 7, which they thought best fit the stimuli. Ss in the second group (constrained) were required to use only a specified number of piles for the stimuli each member was "yoked" to a member of the first group. The free-sort group was found to be more efficient than the constrained-sort group in that it took the constrained group twice as many trials to reach criterion using high frequency words and four times as many trials using low frequency words than the free-sort group. Criterion was set at two nearly identical repetitions of the sort.

The explanation given for the difference between the groups is a "suppression of conceptualization" (Mandler, 1967) on the part of the constrained Ss causing interference in categorization. That is, because the constrained group was forced to use the number of piles that had been imposed upon them, they were not free to order the words in the way which seemed best.

The criterion itself may have been a source of interference on performance. Mandler and Pearlstone (1966) report that the free-sort group took 3.5 trials to learn 19.7 words out of 52 possible. Similarly, in a series of experiments Mandler (1967) reports that Ss in experiment B (second of seven) took 6.9 trials to learn 23.4 words and Ss in experiment D (fourth of seven) took 6.2 trials to learn 28.2 words. Both of these studies involved lists of 52 words with a range of Thorndike-Lorge frequencies. It is possible that a tradeoff exists between S's interest to learn the list and an increase in his interest to match the order of the previous sort causing relatively few words to be recalled.

One of Mandler's (1967) principal findings was a direct relationship between the number of categories and the number of words recalled. Although a relationship has been found (Cofer, 1967, 1968; Bousfield and Cohen, 1956) between these two measures the results are not unequivocal. Dallett (1964) found a relationship for some list types but not for others. The degree of this relationship was seen to vary as a function of category cueing and list length. As Ss were made aware of the number of categories in the list, the relationship between the categories and amount recalled increased. When a list of 24 words was structured in 2, 4, 6, 8 or 12 categories and Ss were not made aware of the number of categories, performance was found to decrease as the number of categories increased.

In recognizing the effect of categorization upon free recall the next step should be to investigate these effects as related to delayed recall. Surprisingly, few investigators have looked into the presence and persistence of clustering in other than immediate recall. Gonzales and Cofer (1966) found a loss of 15-18% of the items in a list following a five minute delay period with interpolated activity. Mandler (1967) provides recall data from .5 weeks to 15 weeks. Forgetting increased rapidly up to about four weeks then leveled off. The results are inconclusive, however, in that the forgetting function is made up of recall percentages from different types of lists which varied in item frequency and list length. Also these results include only about 55% of those Ss tested. He reports that "it appears that memory for organized material shows a sharp initial decay, but no further loss, even after three or four months." (Mandler, 1967, p. 354). Similarly, category recall and RR was seen to decrease over the time periods reported.

Perhaps the most systematic investigations into the retention interval question are Brand (1956) and Brand and Woods (1958). In the second study 60 words are presented to each of two groups. The experimental group receives an initial recall plus three delayed recalls at subsequent 1 week intervals. The control groups receive an initial recall and each group is tested once subsequently; one group at one week, the next at two weeks and the third at three weeks. Out of a total possible recall of 60 words the experimental group recalled 89%, 63%, 60% and 61% for the immediate, one week, two week and three week intervals. The control groups recalled 90%, 55%, 39% and 43% respectively. Cluster scores (RR) for the experimental groups were .38, .28, .32 and .36 for the respective intervals while the control groups showed .365 .22, .21, .16. The additional recalls allowed more words to be recalled and more stability in the clustering than did the single recall for the control groups.

The present experiment will attempt to look more closely at the retention effects on word recall and clustering. While Mandler (1967) reports a leveling in recall percentage after about three weeks, Brand and Woods (1956) find stability after the first week but neither of these investigations examined retention intervals of less than one week to any great extent. Cofer and his associates (Cofer, 1967; Cofer, et. al., 1966) have found an increase in clustering with a decrease in word recall for intervals of five minutes.

Implementation of Mandler's card-sorting technique will be made through the use of free and constrained sorting groups with the following variations: a) matching the amount of practice allotted the two groups,

performance is then expected to be poorer on the part of the constrained group; b) with the elimination of the criterion requirement and addition of a recall following each sort, interference, if any, arising from the criterion requirement is expected to be eliminated.

The experiment will attempt to assess the differential effects of the categorized and random list recall. The assessment will examine differential recall during acquisition but more importantly differential recall at various delay intervals following acquisition.

While a number of experiments have examined specific aspects of clustering, none have provided a comprehensive investigation. The purpose of the present experiment is to examine the effects of sorting technique, list type and retention interval on the number of words recalled, degree of clustering, cluster size and the recall of words of high and low normative frequencies.

METHOD

Subjects

Two hundred forty-nine (249) senior psychology students from three high schools in Harford County, Maryland served as Ss. The three schools were located at least ten miles apart.

Apparatus

Stimulus words were each typed on 3x5 cards. A series of 48 words made up a deck and decks were of two types. One type (categorized) was comprised of six words from each of eight superordinate categories: units of time, metals, alcoholic beverages, sports, weather phenomena, musical instruments, types of vehicles, types of birds. The second type (random) was comprised of 48 unrelated words none of which were chosen from the same conceptual category.

Half of the words in each of the eight categories of the categorized list and half of the random list words were frequent; the other half were infrequent. The Battig and Montague (1969) revision of the norms reported by Cohen, Bousfield and Whitmarsh (1957) was the source of the frequency norms and category members. To arrive at these norms 442 Ss responded by providing items that were considered to be members of a general or superordinate category. High frequency words for the random and categorized lists ranged from 160 to 438, while the low frequency words ranged from 1 to 6. The words and corresponding frequencies are shown in Table 1 (appendix).

Each S received two decks containing the same words. The decks plus a response booklet were enclosed in a manila envelope. Instructions particular to a S were placed on the cover of the envelope.

Procedure

Ss were tested in groups, the number per group varied depending upon the size of the particular class. The learning trials took place in the classrooms in which the Ss took psychology.

Ss were instructed to learn the words on the cards. They were to do this by placing the cards--one at a time--into piles corresponding to words they felt went together. Restrictions were placed upon the sorting procedure in the following manner. Half of the Ss (constrained sort group) could only use four piles while the other half (free sort group) could use from two to eight piles depending upon their own preference. Half of each of these Ss in turn received the categorized list, the other half the random list. Each class was divided equally into the four groups with precautions taken that no two Ss having the same list and sorting instructions would be seated next to another.

Three recall tests, two immediate and one delayed were used. The experimental paradigm consisted of sort-test, sort-test, delay and test. Ss were given a maximum of five minutes for each card sort. Following each sort they numbered the piles and put the numbered piles together into a stack. Cover cards identifying the decks were put in place and the written recall test immediately began. Total time from end of sort to beginning of recall was less than thirty seconds.

The retention intervals employed were: 1 hr., 2 hr., 5 hr., 24 hr., and 168 hrs. (1 wk.). Each class contributed to only one of these intervals. The one week retention group was made up of students from one high school; the 1 hr., 2 hr., 5 hr., 24 hr. groups were contributed to equally by the other two high schools.

All Ss received standard instructions regarding sorting and testing. Ss included in the 1 hr., 2 hr., and 5 hr. groups were told in addition that they would be participating in an additional experiment. The second experiment would be short but due to time limitations they would have to report later that same day to the cafeteria or auditorium (depending upon the school). The 24 hr. and 1 wk. groups were not given such instructions and had no idea they would be seeing E again.

Due to abseeteeism, failure to comply with instructions, cheating, and expressed knowledge of the retention trial, 42 Ss did not complete the task. Of those remaining there were twenty groups with ten Ss per group. The remaining seven were pooled with their respective groups; ten Ss were then chosen at random.

No S reported being constrained by the time factor. Total time for instructions and learning trials was 30 minutes.

RESULTS

A series of measures will be described separately. These measures are as follows: amount recalled, degree of clustering and cluster size. Additional findings described concern a tendency toward reminiscence on the delayed recall, word frequency effects and the number of clusters used during recall. Each of these measures were subjected to an analysis of variance with list type, sorting technique and delay interval as between-Ss variables and trials as a within-S variable. Word frequency was an additional within-S variable for the amount recalled analysis (Butler, Kamlet and Monty, 1969).

Analyses of variance were run on the first recall test (t_1) and the second recall test (t_2) to investigate acquisition effects, while t_2 and the delayed recall test (t_3) were used to investigate the overall retention effects.

Amount Recalled

Table 2 shows the mean number of words recalled for all conditions under investigation. It is apparent that learning the categorized list enhances recall. Analysis of the data substantiated the significance of the higher recall for the categorized list group, $F(1,180) = 101.22, p < .001$ and $F(1,180) = 91.07$, $p < .001$, for both pairs of trials (Tables 9 and 10, appendix). Similarly, the sorting technique was found to affect the amount of recall. The free-sort group recalled more words than the constrained-sort group. Analysis odf the amount recalled by sorting technique substantiated the superiority of the free-sort group, $F(1,180) = 17.77$, $p < .001$ and $F(1,180) = 18.32, p < .001$, for both pairs of trials (Tables 9 and 10, appendix). The significant effect of Trials shown in Table 9 (appendix), $F(1,180 = 1660.05, p < .001$, reflects the increased performance due to acquisition from t_1 to t_2. No other acquisition effects reached the .05 significance level.

From Table 2 it is apparent that the number of words recalled decreases from t_2 to t_3 and the decrement is seen to increase as the interval increases. The Delay Interval effect was found to be significant indicating that performance varied inversely with the interval, $F(1,180) = 8.68, p < .001$. The data underlying the significant Trials x Delay Interval interaction, $F(4,180) = 53.11, p < .001$ (Table 10, appendix), are shown in Figure 1. It can be seen that the slopes of the lines increase directly with increases in the delay interval reflecting forgetting.

When the delayed recall data (t_3) were transferred into percentages of t_2 recall in order to take into account differential individual performance on t_2, the analysis showed a significant forgetting effect, $F(1,180) = 51.87$, $p < .001$. The means over the respective delay intervals were: 95%, 92.6%, 92.2%, 89.5% and 61.6%. The categorized list group recalled a higher percentage of the words recalled on t_2 than the random list group (89% vs. 83%). This effect proved to be statistically significant, $F(1,180) = 12.6, p < .01$. No other effects reached the .05 level of significance.

TABLE 2

MEAN NUMBER OF WORDS RECALLED FOR t_1, t_2 AND t_3 BY VARIABLE

VARIABLE	TRIAL 1		TRIAL 2		TRIAL 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	19.06	5.54	30.49	6.43	25.54	8.57
CATEGORIZED	26.97	5.78	38.04	5.61	34.01	7.29
SORTING TECHNIQUE						
FREE	24.56	7.13	35.93	7.18	31.49	8.78
CONSTRAINED	21.47	6.30	32.60	6.64	28.06	8.93
DELAY INTERVAL						
1 hr.	23.85	6.57	35.10	7.02	33.43	7.48
2 hrs.	22.68	7.37	33.10	7.89	31.03	8.64
5 hrs.	23.58	6.28	34.88	6.17	32.23	7.26
24 hrs.	22.20	7.07	34.33	7.55	30.93	8.53
1 wk.	22.78	7.06	33.93	6.83	21.28	7.48

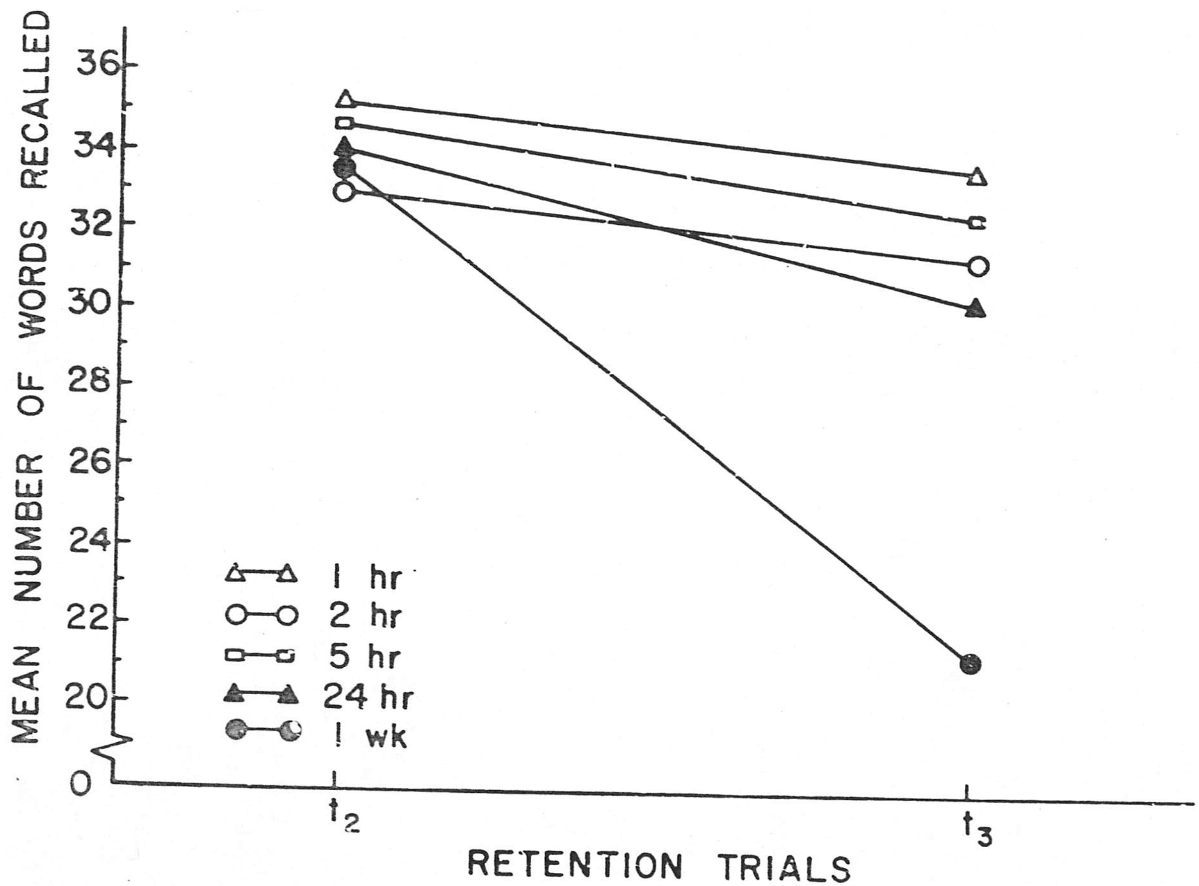

Fig. 1. MEAN NUMBER OF WORDS RECALLED ON t_2 AND t_3 AS A FUNCTION OF DELAY INTERVAL

In summary, the categorized list and free-sort groups recalled more words than the random list and constrained-sort groups. Forgetting increased directly as a function of delay interval with the categorized list group recalling a higher percentage of the words learned on t_2 than the random list group.

Word Frequency

Because both list types were comprised of equal numbers of high and low normative frequency words it was possible to examine differences in the contribution of each to the overall mean recall. Tables 3a and 3b show the mean frequent and infrequent word recall data for the three trials by variable. It is apparent from the table that more frequent than infrequent words were recalled over the three trials. Analysis of the data substantiated the general superiority of the frequent words, $F(1,180) = 437.83$, $p < .001$ and $F(1,180) = 400.38, p < .001$, for both sets of trials (Tables 9 and 10, appendix).

The frequency data for the acquisition trials were analyzed as shown in Table 9 (appendix). The analysis revealed a significant interaction of Trials x Frequency x List Type, $F(1,180) = 12.96, p < .001$. These data are summarized in Figure 2. It can be seen that on t_1 the categorized list group recalled proportionately more frequent than infrequent words when compared to the random list group. The difference disappears on t_2.

The analysis of the frequency effects on word recall as shown in Tables 9 and 10 (appendix) also revealed a significant interaction of Frequency x List Type x Sorting Technique, $F(1,180) = 4.52, p < .05$ and $F(1,180) = 3.06, p < .05$, for both sets of trials. The data underlying this interaction are presented in Figure 3. Immediately apparent upon inspection of the figure is the maintenance of the respective positions of the groups over the sets of trials indicating the stability with which the frequent and infrequent words are recalled. No difference was found between the recall of frequent words for the random list group and infrequent words for the categorized list group. It is within these two groups that the greatest difference between recall by the free-sort and constrained-sort groups exist. The arrangement of the recall scores appears to be evidence of an additional hierarchy in the coding process.

In a subsequent analysis of variance of Frequency x Delay Interval no difference was found in the slopes of the forgetting function for frequent and infrequent words, $F(4,195) = 1.67$, n.s.

In short then, the results indicate that more frequent than infrequent words are recalled. This finding is seen to substantiate Bousfield, Cohen and Whitmarsh (1958). Higher recall of frequent words was found for the categorized list group than the random list group for all three trials. On t_1 the categorized list group recalled proportionately more frequent words than the random list group. The difference disappears on t_2 and t_3. A possible explanation of this effect might be that the categorized list group was able to learn the rules of categorization more quickly than the random

TABLE 3a

MEAN NUMBER OF HIGH NORMATIVE FREQUENCY WORDS RECALLED FOR t_1, t_2, AND t_3 BY VARIABLE

VARIABLE	TRIAL 1		TRIAL 2		TRIAL 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	11.28	3.31	17.41	3.59	15.20	4.51
CATEGORIZED	16.37	3.14	21.34	2.35	19.53	3.47
SORTING TECHNIQUE						
FREE	14.54	4.09	20.09	3.66	18.18	4.33
CONSTRAINED	13.11	4.01	18.66	3.42	16.55	4.66
DELAY INTERVAL						
1 hr.	14.15	4.24	19.63	3.54	18.75	3.66
2 hrs.	13.90	4.45	18.60	4.26	17.55	4.60
5 hrs.	13.75	3.75	19.98	3.10	18.78	3.94
24 hrs.	13.48	4.07	19.70	3.46	18.28	3.87
1 wk.	13.85	3.97	18.98	3.41	13.48	4.43

TABLE 3b

MEAN NUMBER OF LOW NORMATIVE FREQUENCY
WORDS RECALLED FOR t_1, t_2 AND t_3 BY VARIABLE

VARIABLE	TRIAL 1		TRIAL 2		TRIAL 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	7.88	3.10	12.97	4.05	10.77	4.74
CATEGORIZED	10.57	3.47	16.66	4.19	14.55	4.66
SORTING TECHNIQUE						
FREE	10.52	3.77	15.72	4.49	13.68	4.92
CONSTRAINED	8.36	3.13	13.81	4.29	11.64	4.98
DELAY INTERVAL						
1 hr.	9.70	3.15	15.50	4.34	14.55	4.35
2 hrs.	8.73	3.52	13.93	4.57	14.00	4.13
5 hrs.	9.48	3.14	14.90	4.48	14.20	4.30
24 hrs.	8.73	3.97	14.60	4.79	12.85	5.22
1 wk.	9.30	3.84	14.90	4.15	7.70	3.72

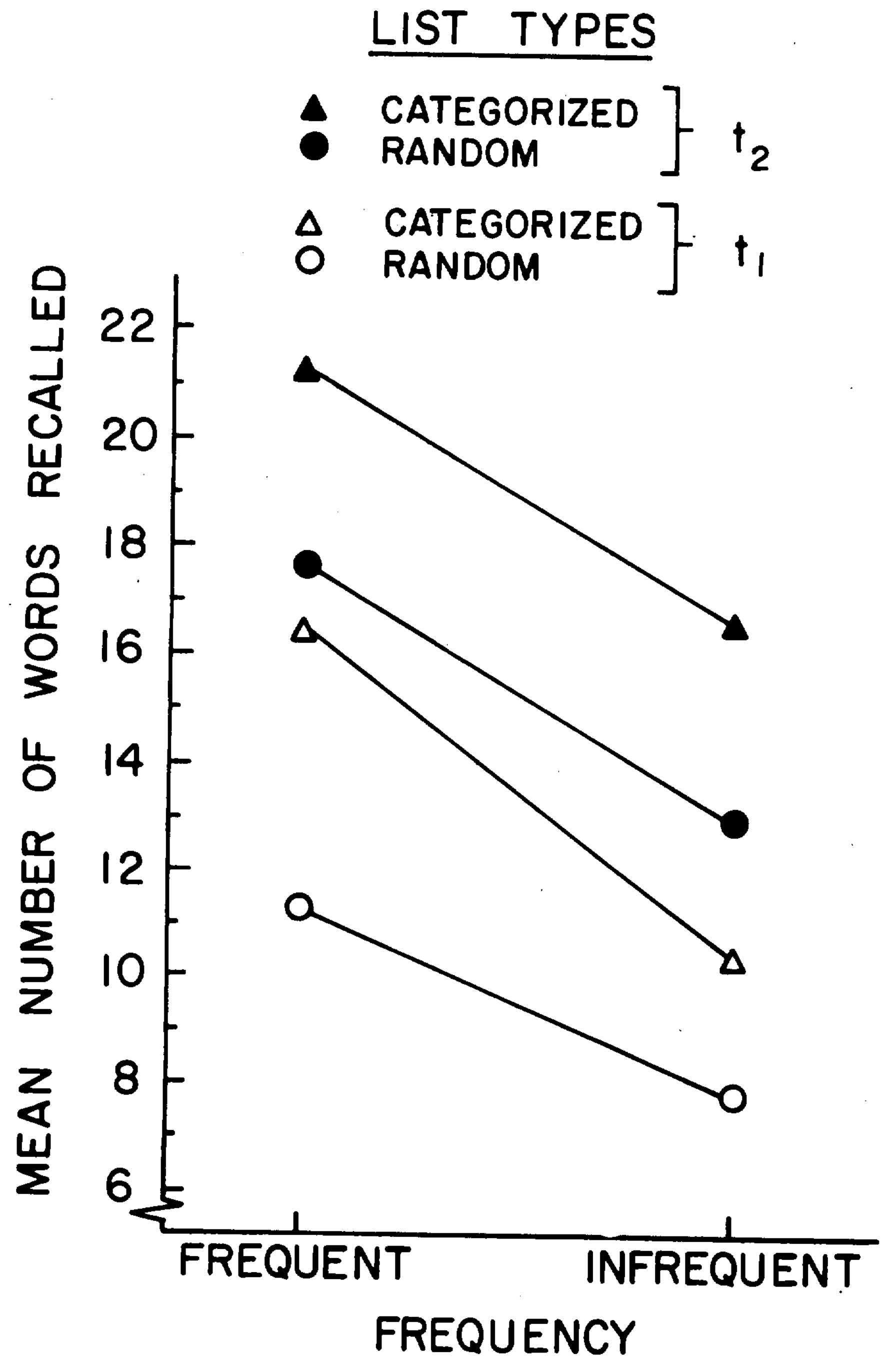

Fig. 2. MEAN NUMBER OF FREQUENT AND INFREQUENT WORDS RECALLED AS A FUNCTION OF LIST TYPE ON t_1 AND t_2

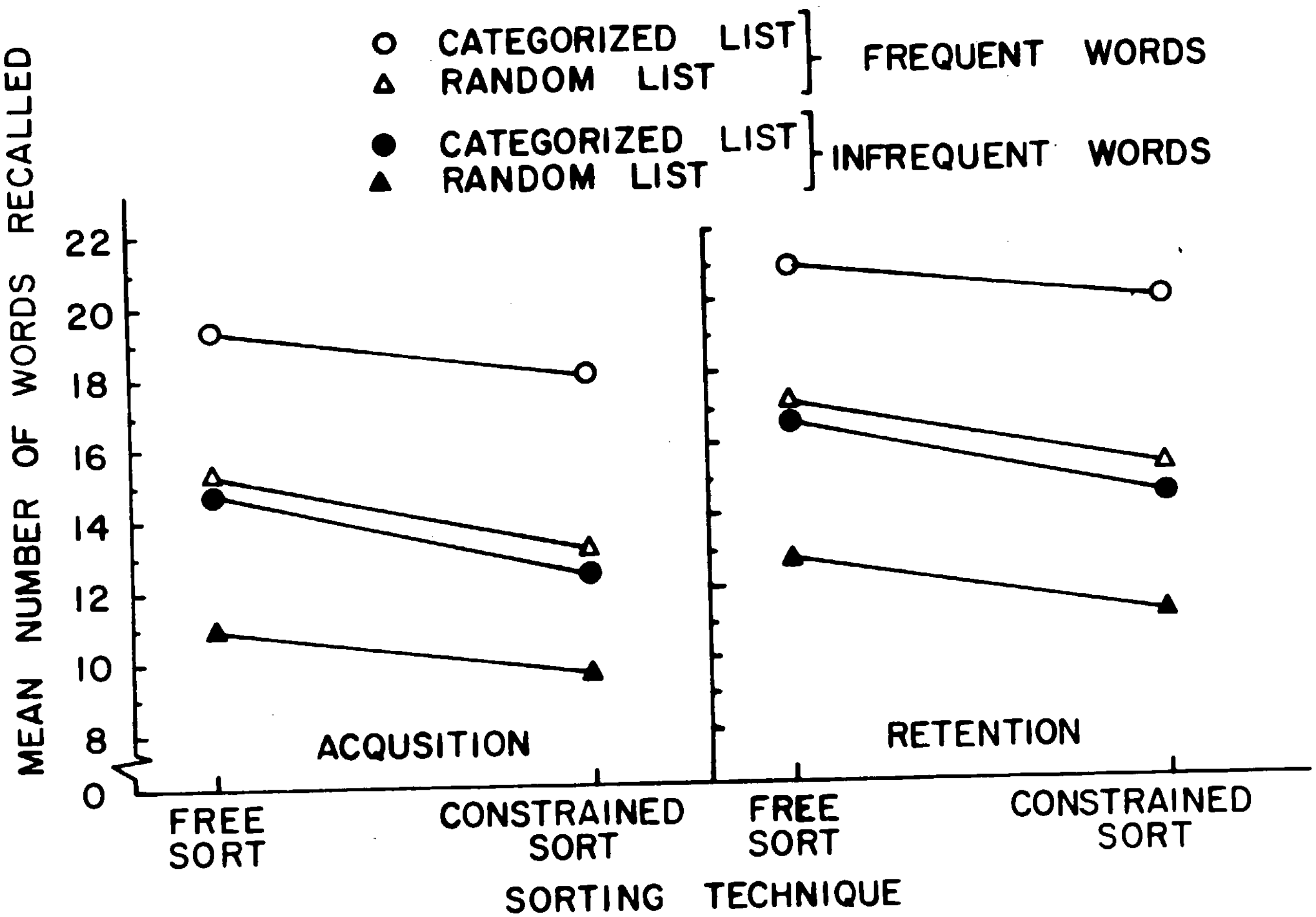

Fig. 3. MEAN NUMBER OF FREQUENT AND INFREQUENT WORDS RECALLED AS A FUNCTION OF LIST TYPE AND SORTING TECHNIQUE DURING ACQUISITION AND RETENTION

list group because of the built-in structure of the list. This allowed them to concentrate upon the frequent words thereby enhancing the recall. No difference was found in the rate of forgetting frequent and infrequent words.

Degree of Clustering

DC = c/N, where c is the total number of words included in strings of two or more words from the categories defined by S. N is equal to the total number of words recalled. For example, in the series xxxxyxzyyyxyyzzz, DC = .75. The traditional clustering measure (RR = r/N-1) has been modified in order to take into account the transition from one category to another, a weakness pointed out by Schuell (1969). The traditional measure reflects perfect clustering (1.00) only when one category is represented in recall. The measure used here reflects perfect clustering (1.00) when any number of categories are represented and all words recalled are in clusters. In this and subsequent assessments of categorization, the categories are those defined by S in the sorting task.

The mean DC scores for the three experimental variables are shown in Table 4. From the table it is seen that clustering increases from t_1 to t_2 and falls off from t_2 to t_3, with overall mean DC scores of .77, .83 and .79 for the three trials. Analysis of the cluster scores revealed a significant Trials effect, $F(1,180) = 28.83, p < .001$ and $F(1,180) = 17.45, p < .001$ for both sets of trials. This increase and decrease in clustering reflects the effects of acquisition and retention. The categorized list group is seen to produce more clustering than the random list group, $F(1,180) = 124.1$, $p < .001$ and $F(1,180) = 102.1, p < .001$ for both sets of trials. Tables 11 and 12 (appendix) summarize the analysis.

The divergent means and S.D. of the two hour group caused a significant effect of Delay Interval (Tables 11 and 12, appendix). When these data were left out of the analysis, Delay Interval effects were no longer present (Tables 13 and 14, appendix). Although DC decreased from t_2 to t_3 the decrease cannot be attributed to the increasing delay interval. There are two possible explanations for the decrease. First, it is possible that the sorting task itself has a positive effect upon DC and when the sort is not present, that is on t_3, DC decreases. Second, the magnitude of the testing terms used in the analysis of variance may account for the decrease. The testing term for the within-Ss variables is one-third the size of the between-Ss error term thus increasing the size of the F ratio.

With the removal of the two hour group's data the mean DC scores for the random list group were .68 and .77 while the categorized list group had means of .89 and .91 for t_1 and t_2 respectively. Analysis of these data showed a significant interaction of Trials x List Type, $F(1,144) = 7.80$, $p < 0.1$. The DC scores for the free-sort groups were .85 and .79 on t_2 and t_3 while the constrained-sort group had DC scores of .83 and .82 for the same trials. The data analysis indicated a significant Trials x Sorting Technique interaction, $F(1,144 = 4.11, p < .05$, Tables 13 and 14 (appendix).

TABLE 4

MEAN DC SCORES FOR t_1, t_2 AND t_3 BY VARIABLE

VARIABLE	TRIAL 1		TRIAL 2		TRIAL 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	.663	.190	.748	.166	.694	.199
CATEGORIZED	.884	.105	.912	.103	.891	.102
SORTING TECHNIQUE						
FREE	.770	.205	.826	.173	.773	.209
CONSTRAINED	.778	.171	.834	.148	.813	.158
DELAY INTERVAL						
1 hr.	.812	.144	.835	.141	.819	.157
2 hrs.	.718	.216	.777	.209	.739	.213
5 hrs.	.802	.157	.852	.142	.845	.131
24 hrs.	.758	.214	.853	.139	.797	.180
1 wk.	.780	.187	.832	.151	.763	.216

In summary DC scores are not affected by increasing delay intervals; however, clustering was seen to decrease from t_2 to t_3. The categorized list group has a high DC score on t_1 and remains steady while the random list group starts clustering at a low level and increases rapidly to t_2. DC differences occurring on t_3 of .73 and .89 are not significant. List Type proved to be the most important variable in clustering. The DC scores were seen to decrease from t_2 to t_3 for the free-sort group while the constrained-sort group remained stable.

Cluster Size

Cluster size is the ratio of the number of clustered words (c) and the number of clusters (k) used. The number of clusters could vary between two and twenty-four. Table 5 shows the mean cluster size for the three primary variables.

It is apparent that the categorized list group recalled larger clusters than the random list group. Analysis of the data confirmed the significance of the differences in cluster size by List Type, $F(1,180) = 68.18, p < .001$ and $F(1,180) = 50.61, p < .001$. The constrained-sort group was found to recall in larger clusters than the free-sort group, $F(1,180) = 12.23, p < .001$ and $F(1,180) = 12.03, p < .001$. The analyses for cluster size also revealed a significant interaction of Trials x Sorting Technique, $F(1,180) = 6.7, p < .05$ and $F(1,180) = 36.57, p < .001$, (Tables 15 and 16, appendix).

Figure 4 shows the data underlying the Trials x Sorting Technique interaction. The difference in the slope of the lines indicates more stability in the size of the clusters of the free-sort group. The constrained-sort group used larger clusters during recall than the free-sort group but recalled less words (Table 2). During t_1 and t_2 the constrained-sort Ss had been forced to use four categories requiring the same number of words to be put into fewer categories than the free-sort group. More words were remembered per category but because the number of category members exceed S's memory capacity, less total words were recalled. The use of more categories with less words per category on the part of the free-sort Ss resulted in more efficient organization and less of a decrement, .32 vs. .67 words per cluster, on t_3. These findings are again consistent with the coding interpretation. Delay Interval had no effect on cluster size.

Additional Findings

Of particular interest in an investigation of memorial properties are the data concerned with the appearance of words on t_3 that had not been previously recalled. These data have relevance to the discussion of Tulving and Pearlstone (1966) on the accessibility and availability of items in storage.

Table 6 shows the mean number of words recalled on t_3 that were not recalled on t_1 or t_2. From the table it becomes apparent that the categorized

TABLE 5

AVERAGE CLUSTER SIZE USED DURING RECALL ON t_1, t_2, and t_3

VARIABLE	TRIAL 1		TRIAL 2		Trial 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	2.83	.76	3.60	1.53	3.15	1.26
CATEGORIZED	4.05	1.20	5.00	1.74	4.43	1.42
SORTING TECHNIQUE						
FREE	3.29	.88	3.89	1.24	3.55	1.11
CONSTRAINED	3.59	1.39	4.71	2.11	403	1.75
DELAY INTERVAL						
1 hr.	3.38	.85	4.50	2.23	4.11	1.91
2 hrs.	3.15	.86	3.89	1.31	3.38	1.01
5 hrs.	3.55	1.09	4.38	1.51	4.07	1.39
24 hrs.	3.42	1.08	4.34	1.60	4.01	1.52
1 wk.	3.68	1.71	4.42	2.07	3.37	1.24

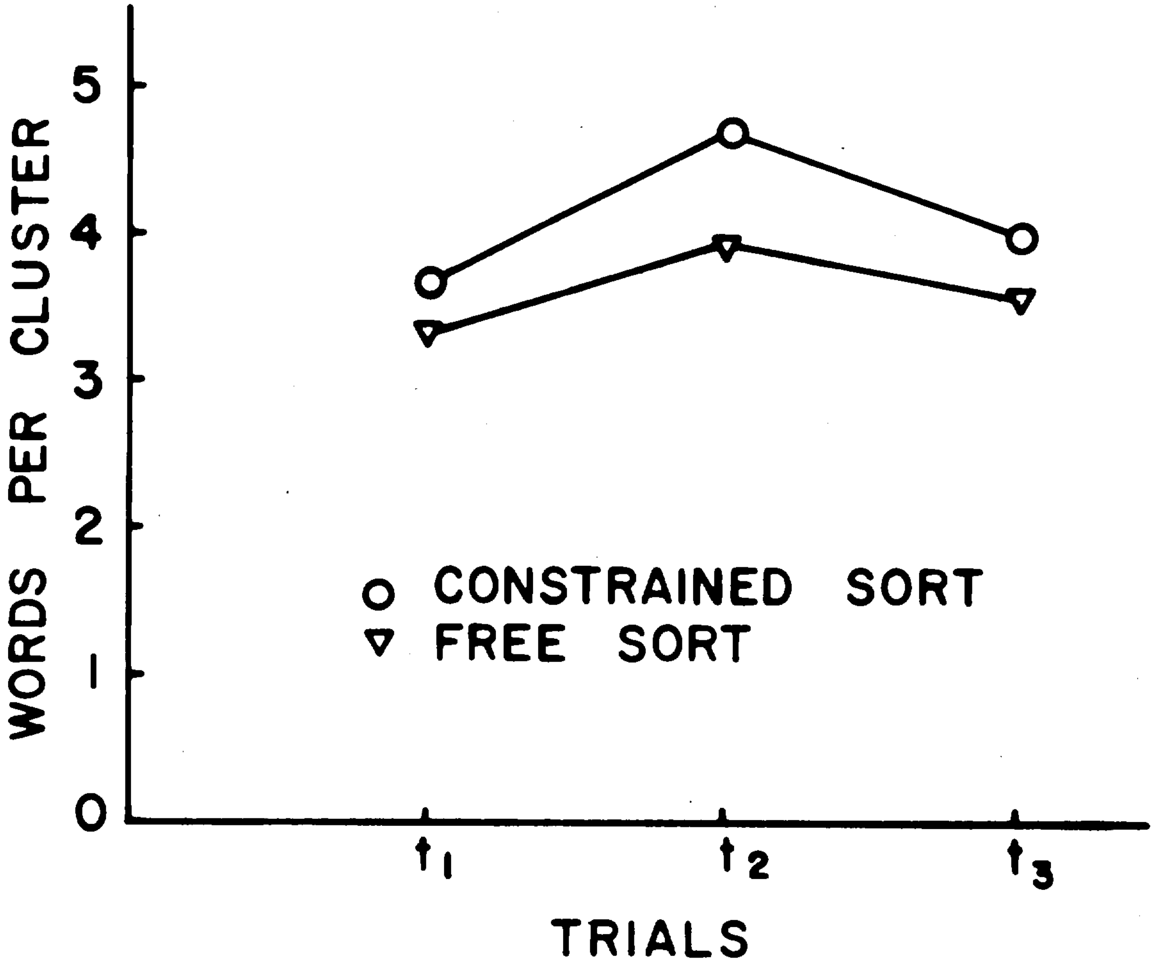

Fig. 4. CLUSTER SIZE ON t_1, t_2 AND t_3 AS A FUNCTION OF SORTING TECHNIQUE

TABLE 6

WORDS ADDED DURING DELAYED RECALL NOT RECALLED ON t_1 OR t_2

	CATEGORIZED LIST			RANDOM LIST	
	FREE SORT	CONSTRAINED SORT		FREE SORT	CONSTRAINED SORT
	9	22		19	20
	4	23	2 hrs.	16	22
	7	18	5 hrs.	24	31
	7	13	24 hrs.	17	27
	2	11	1 wk.	10	18
(A)	29	87		86	118
TOTAL POSSIBLE	2400	2400		2400	2400
AMT. RECALLED (t_2)	1992	1812		1603	1450
DIFF. (B)	408	588		797	950
% A/B	.073	.148		.108	.125

list group recalls less additional words than the random list group and the free-sort group less than the constrained-sort group. Analysis of the data supports the significance of these variables, $F(1,180) = 19.9, p < .001$ for each main effect variable (Table 17, appendix). Because there was no opportunity between t_2 and t_3 for Ss to examine the list, it must be assumed that the words were learned before t_2 but not accessible to retrieval at that time. No other differences reached the .05 significance level.

Number of Clusters

An examination of the number of clusters (k) used during recall by S is relevant to the possibility of a limited memory capacity caused by a limitation of the storage and retrieval processes. The range for the number of clusters used in the present study was 1 to 12 with means of 5.38, 7.09 and 6.49 for t_1, t_2 and t_3. Analysis of these data revealed this to be a significant effect, $F(1,180) = 159.15, p < .001$ and $F(1,180) = 19.03, p < .001$, for both sets of trials.

Table 7 shows the mean number of clusters on t_1, t_2 and t_3 for the three variables being investigated. The data underlying the significant main effects indicated that the categorized list group recalled more clusters than the random list group for both sets of trials, $F(1,180) = 32.53, p \quad .001$ and $F(1,180) = 20.83, p < .001$. Similarly, the data underlying the main effect of Sorting Technique was significant for both sets of trials, $F(1,180) = 43.88$, $p < .001$ and $F(1,180) = 36.17, p < .001$. With respect to the significant interaction of Trials x List Type, $F(1,180) = 10.59, p < .001$ and $F(1,180) = 5.83, p < .05$, it can be seen in Figure 5 that the random list group takes longer to learn the rules for attaching labels in order to form clusters than the categorized list group. By t_2 both groups are using approximately the same number of clusters but the clusters seem to be less stable for the random list group as clusters are lost on t_3.

The data underlying the significant interaction of List Type x Sorting Technique, $F(1,180) = 4.29, p < .05$, for the acquisition trails are summarized in Figure 6. From the figure it can be seen that the decrement in the number of clusters used by the random list free-sort group and the categorized free-sort group was greater than the decrement for the respective constrained groups. The number of clusters used during recall was greater for the categorized list group, the greatest number of clusters occurring in the free-sort condition.

The data underlying the effect of Delay Interval, $F(4,180) = 4.85$, $p < .01$, and the interaction of Trials x Delay Interval, $F(4,180) = 7.5, p < .001$, are shown in Figure 7. A comparison of t_2 and t_3 can be made by comparing the open and closed triangles. The number of clusters is seen to vary inversely with the delay from t_2 to t_3. The curve closely resembles the forgetting effects seen in Figure 1; as clusters are lost words are forgotten. The analyses for the data for the number of clusters is found in Tables 18 and 19 (appendix).

TABLE 7

MEAN NUMBER OF CLUSTERS USED
DURING RECALL ON t_1, t_2 and t_3

VARIABLE	TRIAL 1		TRIAL 2		TRIAL 3	
	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
LIST TYPE						
RANDOM	4.60	1.73	6.77	2.18	5.83	2.39
CATEGORIZED	6.16	1.63	7.44	1.79	7.14	1.60
SORTING TECHNIQUE						
FREE	5.89	1.98	7.89	1.89	7.00	2.20
CONSTRAINED	4.87	1.55	6.32	1.83	5.97	1.94
DELAY INTERVAL						
1 hr.	5.85	1.68	7.33	2.13	7.23	1.72
2 hrs.	5.35	2.20	6.73	1.95	6.75	1.06
5 hrs.	5.45	1.56	7.40	2.33	7.08	1.91
24 hrs.	5.10	1.96	7.10	1.53	6.45	2.09
1 wk.	5.15	1.68	6.98	1.99	4.93	2.05

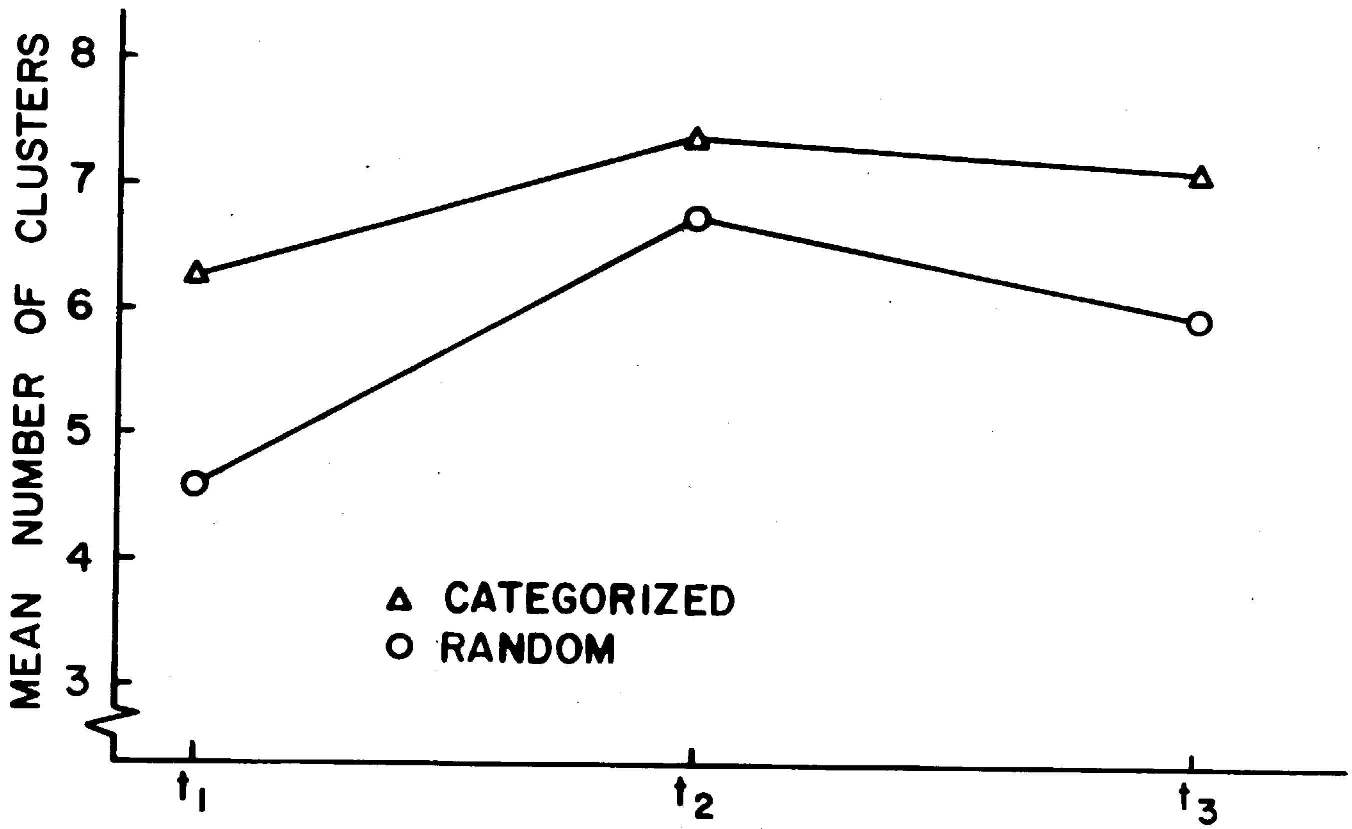

Fig. 5. MEAN NUMBER OF CLUSTERS RECALLED ON t_1, t_2 AND t_3 AS A FUNCTION OF LIST TYPE

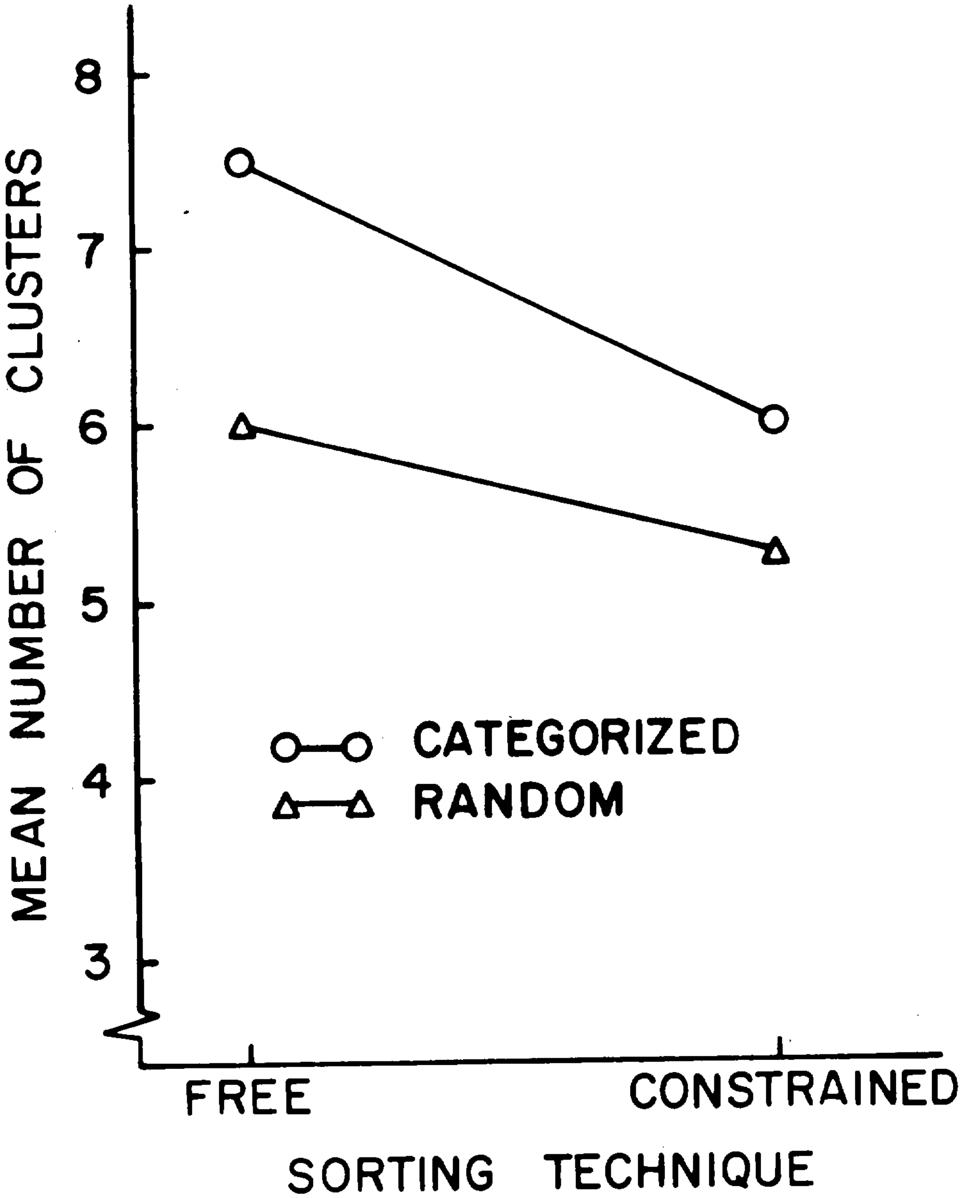

Fig. 6. MEAN NUMBER OF CLUSTEREDS RECALLED DURING ACQUISITION AS A FUNCTION OF LIST TYPE AND SORTING TECHNIQUE

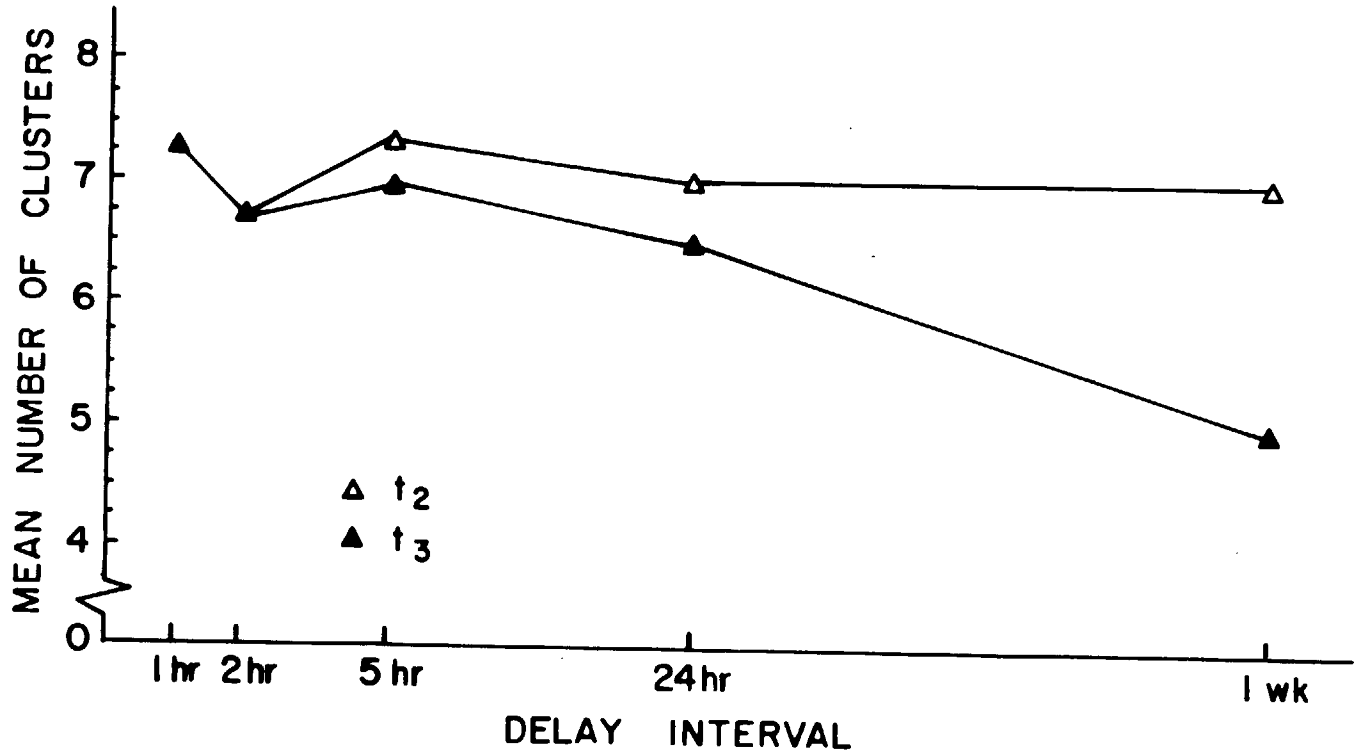

Fig. 7. MEAN NUMBER OF CLUSTERS RECALLED AS A FUNCTION OF DELAY INTERVAL ON t_2 AND t_3

In summary, the number of clusters was highest for the categorized list group and free-sort group. Clusters decreased as the delay interval increased.

Due to an insufficient amount of appropriate data the relationship between the number of categories (piles) employed and number of words recalled could not be assessed. Too few (5) Ss in the categorized free-sort group used other than eight categories. Twenty out of fifty used eight piles for the free-sort random list. The resulting correlations are: $r_{t1} = -.092$, $r_{t2} = .05$, $r_{t3} = .015$; none of these correlations reach significance.

Although the free-sort group was superior to the constrained-sort group in amount recalled, a possible confounding of the data has occurred. Table 8 shows the data for the random list Ss. The free-sort group using 4 or 5 piles did better than the constrained group on t_1 recall. The difference disappears on the subsequent trials.

All but five of the free-sort categorized list group used eight piles and had higher recalls on the three trials than the constrained-sort categorized list group. This is equivalent to saying that Ss using eight piles did better than those using four piles giving support to the Mandler (1967) hypothesis that a linear relationship exists between the number of piles (categories) and the amount recalled. However, the lack of correlation between the number of piles and words recalled for the random list complicates the significance of the support.

DISCUSSION

The major finding of this study was the differential effects of the Delay Interval upon the variables investigated. The number of words recalled and the number of clusters used were found to decrease as the delay interval increased. There were no differential effects upon the degree of clustering, cluster size, words added during t_3 and word frequency.

These results regarding Delay Interval are in partial agreement with the equivocal results of previous investigations. Brand and Woods (1958) and Mandler (1967) reported a decrease in clustering (RR) and a decrease in word recall while Cofer (1967) reports an increase in clustering and a decrease in recall. In addition, forgetting appeared to be related to the loss of clusters rather than words within the clusters. This interpretation is in agreement with Cohen's (1966) "some-or-none" characteristics of coding with the modification of clusters rather than categories.

Rather unexpectedly, word frequency was not a significant factor affecting performance. Frequent and infrequent words were forgotten at the same rate. The categorized list group recalled more frequent and infrequent words than the random list group. The differences stayed the same over the

TABLE 8

AMOUNT RECALLED -- RANDOM LIST

SORT TYPE	MEAN	N	df	t	p
TRIAL 1					
FREE	21.25	12			
CONSTRAINED	17.70	50	60	2.25	.01
TRIAL 2					
FREE	30.55	11			
CONSTRAINED	28.98	50	59	.77	n.s.
DELAYED RECALL					
FREE	26.6	11			
CONSTRAINED	23.5	50	59	1.11	n.s.

three trials except for t_1 where the categorized list group recalled proportionately more frequent words than the random list group. The reason for the difference on t_1 is that the structure of the categorized list enabled S to concentrate more on learning the words than on the rules of organization. During recall more frequent words were remembered.

The lack of differential forgetting of frequent and infrequent words adds additional support to Cohen's "some or none" hypothesis. If the clusters were made up of a consistent ratio, i.e. 2:1, of frequent to infrequent words the loss of clusters over the delay interval would reflect the lack of differences in the slope of the forgetting curve.

The effect of List Type was the single most important determiner of performance. This result confirms the previous investigations on the superiority of the categorized list learning.

The constrained-sort group recalled words in larger clusters than the free-sort group but generally the free-sort group exhibited superior performance. Sorting Technique did not affect the degree of clustering or forgetting when the percentage data was used. The direction of the word recall data supports the finding of Mandler and Pearlstone (1966); however, there is a large discrepancy in the magnitude of the differences. With an equal number of trials the free-sort group did not recall twice as many frequent and four times as many infrequent words as the constrained-sort group.

The experiment provided support for two hierarchical coding systems. The first is task related while the second is related to the limits of memory.

Analysis of the amount recalled, cluster size, number of clusters and added words yielded the following hierarchy. The free-sort categorized list group had the best overall performance. Recall and clustering performance were about equal for the constrained-sort categorized list group and the free-sort random list group while the constrained-sort random list group was invariably poorest.

Regardless of the type of list learned S was able to form superordinate categories. Within the superordinate categories were clusters of words which varied in length and were related in some way, i.e. associates or similar category members. Miller (1956) proposed a structure with limits of 7 ± 2 on the superordinate categories and subordinate members. Mandler (1967) suggested that Miller's estimate was too high and should be revised to 5 ± 2 on the basis of the results of his studies. The results of the present experiment indicate that the number of clusters used is within the limits specified by Miller (1956) while the size of the clusters is more closely aligned to Mandler's (1967) estimate.

Storage and Retrieval

Tulving and Pearlstone (1966) have addressed themselves to the problem of storage and retrieval. Briefly, items learned are stored in memory as traces. Trace availability is determined by the number or amount present, similarity, and temporal factors. The accessibility of the traces depends upon their availability but also and primarily upon facilitory cues; i.e. associations. These investigators have hypothesized a dual level retrieval system. The high order system contains superordinate labels and may be associative or organizational. The lower order system contains associates or category members.

Tulving and Pearlstone (1966) set forth a number of "critical experimental treatments" to demonstrate availability and accessibility; however, the general importance of the concept makes it applicable to the present situation. A type of reminiscence effect was shown in Table 6 by the number of words that were recalled on t_3 and not on t_1 or t_2. From the data it appears that there were two possible sources of cueing.

The results of the experiment raise the possibility of the existence of two implicit cue sources. These cue sources were List Type and Sorting Technique. The categorized list had categories built into it; the random did not. The free-sort group was free to choose the number of piles, the constrained-sort group could not. The categorized list and free-sort conditions act as positive cue factors.

Depending upon the presence or absence of the positive retrieval cues additional words are recalled. The categorized list free-sort group had both positive cues and recalled the most t_2 and added the least new words. By contrast the random list constrained-sort - two negative cues - had poorest recall at t_2 and added the most words. The remaining two groups with one negative cue had about equal additional word recall. Due to forgetting memory load has decreased making previously unavailable words available. There is no retention interval effect because with shorter intervals less words are forgotten and with the longer intervals the old and new words are forgotten.

The experiment substantiated previous findings of subjective organization even when the lists are structured (Cofer, 1965; Tulving, 1966; Mandler, 1967). The nature of the organization has been found to vary along categorical as well as associative dimensions (Deese, 1959) and therefore should not be and cannot be separated into distinct types to determine the causes of recall (Schuell, 1969).

Some procedural differences exist between the present study and the Mandler and Pearlstone (1966) study. The present study used groups of Ss while the latter used individual Ss. This difference made it impossible for the present study to impose the additional constraint of category composition. That is, Mandler and Pearlstone forced the constrained Ss to put the same words into the same piles as the free-sort group had done. This additional constraint tied to the criterion requirement probably accounted for the difference in word recall. During the present study, using frequent and

infrequent words, Ss recalled 23.0, 34.27 and 29.78 for the three trials respectively, while the Mandler and Pearlstone Ss were recalling only 19.65 out of 52 high frequency words after 3.5 and 7.5 trials for the free and constrained groups respectively.

In subsequent studies Mandler (1967) found a linear relationship between the number of categories and amount recalled. The present experiment failed to confirm this finding. A relationship did exist, however, between the number of clusters and amount recalled. Because the free-sort categorized group almost entirely used eight categories during the sort, the only data source for the categories and amount recalled relationship was the free-sort random list group. This group was also used for the comparison of the number of clusters to amount recalled. For the three trials the correlations were: $r_{t1} = .78$, $r_{t2} = .56$ and $r_{t3} = .79$.

Although the emphasis in this study is upon the clusters to recall relationship while Mandler (1967) emphasized the categories to recall relations, the direct relationship between organization and recall has been substantiated (Bousfield and Cohen, 1956; Mandler, 1967; Dallett, 1964).

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APPENDIX

TABLE 1

CATEGORIZED WORD LIST AND WORD FREQUENCY

1. A Unit of Time	
hour	(433)
minute	(430)
second	(426)
moment	(4)
infinity	(5)
epoch	(1)
2. A Metal	
iron	(353)
copper	(309)
steel	(281)
gallium	(1)
antimony	(2)
palladium	(2)
3. An Alcoholic Beverage	
beer	(334)
whiskey	(323)
gin	(308)
gimlet	(1)
chianti	(3)
cognac	(9)
4. A Sport	
football	(396)
baseball	(376)
basketball	(360)
billiards	(1)
curling	(1)
skating	(4)
5. A Weather Phenomenon	
hurricane	(318)
tornado	(303)
rain	(297)
arid	(1)
zephyr	(1)
humid	(1)
6. A Musical Instrument	
piano	(329)
drum	(322)
trumpet	(279)
kazoo	(1)
lyre	(1)
zither	(4)
7. A Type of Vehicle	
car	(407)
bus	(300)
airplane	(280)
sleigh	(1)
ferry	(1)
stagecoach	(1)
8. A Type of Bird	
robin	(377)
sparrow	(237)
cardinal	(208)
roadrunner	(1)
egret	(5)
sandpiper	(1)

TABLE 1 (cont)

RANDOM WORD LIST AND WORD FREQUENCY

diamond	(435)	naptha	(2)
yeoman	(1)	portico	(1)
armoire	(1)	fornication	(2)
hour	(433)	butler	(1)
badger	(1)	oxygen	(294)
legs	(402)	hammer	(431)
aunt	(432)	mountain	(401)
alpaca	(2)	piano	(329)
guava	(1)	shirt	(352)
mile	(438)	football	(396)
auburn	(2)	dollar	(331)
gun	(394)	Hurricane	(318)
antimony	(2)	jazz	(341)
pitcher	(1)	stagecoach	(1)
president	(434)	Kristy	(1)
magazine	(375)	balsa	(4)
mission	(4)	ichthyology	(1)
apartment	(316)	rose	(421)
gimlet	(1)	Harvard	(160)
salt	(412)	tarantella	(1)
clay	(6)	cancer	(316)
Andorra	(1)	expletive	(3)
Chicago	(270)	yams	(1)
waders	(1)	sailboat	(177)

TABLE 9

ANALYSIS OF VARIANCE OF AMOUNT RECALLED DURING ACQUISITION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL, TRIALS AND WORD FREQUENCY

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST (R vs C)	1	2933.8	101.215	.001
SORT (F vs C)	1	515.2	17.775	.0001
LIST x SORTING	1	7.2	.249	
DELAY	4	21.7	.748	
LIST x DELAY	4	9.9	.342	
SORTING x DELAY	4	5.0	.172	
LIST x SORTING x DELAY	4	26.6	.918	
ERROR	180	29.0		
WITHIN Ss VARIABLES				
TRIALS	1	6193.8	1660.054	.0001
TRIALS x LIST	1	1.0	.263	
TRIALS x SORT	1	.8	.226	
TRIALS x LIST x SORTING	1	3.9	1.051	
TRIALS x DELAY	4	7.3	1.949	
TRIALS x LIST x DELAY	4	2.4	.639	
TRIALS x SORT x DELAY	4	4.7	1.268	
TRIALS x LIST x SORT x DELAY	4	2.9	.788	
ERROR	180	3.7		
FREQUENCY (FREQ)	1	4278.1	437.834	.0001
FREQ x LIST	1	92.5	9.469	.001
FREQ x SORT	1	6.1	.627	
FREQ x LIST x SORT	1	44.2	4.521	.05
FREQ x DELAY	4	3.9	.403	
FREQ x LIST x DELAY	4	21.9	2.237	
FREQ x SORT x DELAY	4	1.9	.193	
FREQ x LIST x SORT x DELAY	4	9.8	.999	
ERROR	180	9.8		
TRIALS x FREQ	1	.0	.011	
TRIALS x FREQ x LIST	1	52.0	12.955	.001
TRIALS x FREQ x SORT	1	.8	.210	
TRIALS x FREQ x LIST x SORT	1	.2	.045	
TRIALS x FREQ x DELAY	4	3.3	.834	
TRIALS x FREQ x LIST x DELAY	4	3.8	.937	
TRIALS x FREQ x SORT x DELAY	4	4.9	1.224	
TRIALS x FREQ x LIST x SORT x DELAY	4	4.4	1.090	
ERROR	180	4.0		

TABLE 10

ANALYSIS OF VARIANCE OF AMOUNT RECALLED DURING RETENTION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL, TRIALS AND WORD FREQUENCY

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST (R vs C)	1	3053.7	91.067	.0001
SORT (F vs C)	1	614.3	18.318	.001
LIST x SORTING	1	0.6	0.016	
DELAY	4	291.0	8.679	.01
LIST x DELAY	4	11.6	0.345	
SORTING x DELAY	4	9.9	0.294	
LIST x SORTING x DELAY	4	29.2	0.870	
ERROR	180	33.5		
WITHIN Ss VARIABLES				
TRIALS	1	846.7	190.124	.0001
TRIALS x LIST	1	4.4	0.977	
TRIALS x SORT	1	1.4	0.306	
TRIALS x LIST x SORTING	1	2.1	0.472	
TRIALS x DELAY	4	236.5	53.106	.0001
TRIALS x LIST x DELAY	4	2.9	0.647	
TRIALS x SORT x DELAY	4	3.3	0.737	
TRIALS x LIST x SORT x DELAY	4	1.4	0.314	
ERROR	180	4.5		
FREQUENCY (FREQ)	1	4338.5	400.376	.0001
FREQ x LIST	1	9.9	0.914	
FREQ x SORT	1	9.9	0.914	
FREQ x LIST x SORT	1	33.2	3.065	.05
FREQ x DELAY	4	10.1	0.930	
FREQ x LIST x DELAY	4	42.8	3.947	.01
FREQ x SORT x DELAY	4	10.0	0.922	
FREQ x LIST x SORT x DELAY	4	27.0	2.491	
ERROR	180	10.8		
TRIALS x FREQ	1	0.5	0.127	
TRIALS x FREQ x LIST	1	0.6	0.155	
TRIALS x FREQ x SORT	1	0.1	0.017	
TRIALS x FREQ x LIST x SORT	1	0.2	0.059	
TRIALS x FREQ x DELAY	4	11.2	3.138	.01
TRIALS x FREQ x LIST x DELAY	4	5.3	1.486	
TRIALS x FREQ x SORT x DELAY	4	2.1	0.602	
TRIALS x FREQ x LIST x SORT x DELAY	4	3.6	1.006	
ERROR	180	3.6		

TABLE 11

ANALYSIS OF VARIANCE OF DC SCORES DURING ACQUISITION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	372.9	124.106	.0001
SORT TECH (F vs C)	1	0.8	0.258	
LIST TYPE x SORTING TECH	1	7.2	2.392	
DELAY INTERVAL	4	8.2	2.735	
LIST TYPE x DELAY INT.	4	5.5	1.824	
SORTING TECH x DELAY INT.	4	2.0	0.660	
LIST TYPE x SORTING TECH x DELAY INT.	4	4.2	1.411	
ERROR	180	3.0		
WITHIN Ss VARIABLES				
TRIALS	1	31.5	28.829	.001
TRIALS x LIST TYPE	1	8.0	7.291	.01
TRIALS x SORT TECH	1	0.0	0.000	
TRIALS x LIST TYPE x SORTING TECH	1	0.1	0.127	
TRIALS x DELAY INT.	4	1.3	1.224	
TRIALS x LIST TYPE x DELAY INT.	4	0.4	0.332	
TRIALS x SORT TECH x DELAY INT.	4	3.1	2.875	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	2.2	1.986	
ERROR	180	1.1		

TABLE 12

ANALYSIS OF VARIANCE OF DC SCORES DURING RETENTION
AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE,
DELAY INTERVAL AND TRIALS

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS	199			
LIST TYPE (R vs C)	1	332.5	102.105	.0001
SORT TECH (F vs C)	1	5.5	1.686	
LIST TYPE x SORTING TECH	1	15.0	4.602	.05
DELAY INTERVAL	4	10.0	3.073	.05
LIST TYPE x DELAY INT.	4	6.4	1.954	
SORTING TECH x DELAY INT.	4	4.7	1.457	
LIST TYPE x SORTING TECH x DELAY INT.	4	1.6	0.505	
ERROR	180	3.3		
WITHIN Ss VARIABLES				
TRIALS	1	14.7	17.453	.001
TRIALS x LIST TYPE	1	2.2	2.621	
TRIALS x SORT TECH	1	2.6	3.031	
TRIALS x LIST TYPE x SORTING TECH	1	0.4	0.486	
TRIALS x DELAY INT.	4	1.4	1.607	
TRIALS x LIST TYPE x DELAY INT.	4	1.2	1.384	
TRIALS x SORT TECH x DELAY INT.	4	2.6	3.084	.05
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	1.7	2.048	
ERROR	180	0.8		

TABLE 13

ANALYSIS OF VARIANCE OF DC SCORES DURING ACQUISITION
AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE,
DELAY INTERVAL AND TRIALS WITH 2 HR. DELAY INTERVAL DATA OMITTED.

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	159			
LIST TYPE (R vs C)	1	242.5	86.362	.0001
SORT TECH (F vs C)	1	0.0	0.000	
LIST TYPE x SORTING TECH	1	6.3	2.248	
DELAY INTERVAL	3	1.0	0.362	
LIST TYPE x DELAY INT.	3	2.5	0.893	
SORTING TECH x DELAY INT.	3	1.7	0.601	
LIST TYPE x SORTING TECH x DELAY INT.	3	5.6	2.005	
ERROR	144	2.8		
WITHIN Ss VARIABLES				
TRIALS	1	24.6	26.120	.0001
TRIALS x LIST TYPE	1	7.3	7.804	.01
TRIALS x SORT TECH	1	2.2	2.389	
TRIALS x LIST TYPE x SORTING TECH	1	0.2	0.248	
TRIALS x DELAY INT.	3	1.8	1.889	
TRIALS x LIST TYPE x DELAY INT.	3	0.4	0.454	
TRIALS x SORT TECH x DELAY INT.	3	0.4	0.432	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	3	1.8	1.897	
ERROR	144	0.9		

TABLE 14

ANALYSIS OF VARIANCE OF DC SCORES DURING RETENTION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS WITH 2 HR. DELAY INTERVAL DATA OMITTED

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	159			
LIST TYPE (R vs C)	1	212.3	74.533	.0001
SORT TECH (F vs C)	1	0.1	0.033	
LIST TYPE x SORTING TECH	1	9.0	3.177	
DELAY INTERVAL	3	3.5	1.216	
LIST TYPE x DELAY INT.	3	3.4	1.208	
SORTING TECH x DELAY INT.	3	1.0	0.346	
LIST TYPE x SORTING TECH x DELAY INT.	3	1.9	0.650	
ERROR	144	2.8		
WITHIN Ss VARIABLES				
TRIALS	1	11.9	12.725	.001
TRIALS x LIST TYPE	1	2.0	2.200	
TRIALS x SORT TECH	1	3.8	4.107	.05
TRIALS x LIST TYPE x SORTING TECH	1	0.6	0.685	
TRIALS x DELAY INT.	3	1.8	1.936	
TRIALS x LIST TYPE x DELAY INT.	3	1.5	1.649	
TRIALS x SORT TECH x DELAY INT.	3	3.0	3.219	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	3	2.2	2.376	
ERROR	144	0.9		

TABLE 15

ANALYSIS OF VARIANCE OF CLUSTER SIZE DURING ACQUISITION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS.

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	175.7	68.184	.001
SORT TECH (F vs C)	1	31.5	12.227	.01
LIST TYPE x SORTING TECH	1	3.8	1.462	
DELAY INTERVAL	4	3.1	1.218	
LIST TYPE x DELAY INT.	4	5.7	2.207	
SORTING TECH x DELAY INT.	4	1.4	0.534	
LIST TYPE x SORTING TECH x DELAY INT.	4	1.9	0.720	
ERROR	180	2.6		
WITHIN Ss VARIABLES				
TRIALS	1	72.0	71.737	.001
TRIALS x LIST TYPE	1	1.1	1.131	
TRIALS x SORT TECH	1	6.7	6.700	.01
TRIALS x LIST TYPE x SORTING TECH	1	0.0	0.006	
TRIALS x DELAY INT.	4	0.5	0.451	
TRIALS x LIST TYPE x DELAY INT.	4	1.2	1.148	
TRIALS x SORT TECH x DELAY INT.	4	0.5	0.506	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	0.1	0.148	
ERROR	180	1.0		

TABLE 16

ANALYSIS OF VARIANCE OF CLUSTER SIZE DURING RETENTION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	178.6	50.613	.001
SORT TECH (F vsC)	1	42.5	12.031	.01
LIST TYPE x SORTING TECH	1	2.2	0.621	
DELAY INTERVAL	4	6.1	1.724	
LIST TYPE x DELAY INT.	4	7.0	1.977	
SORTING TECH x DELAY INT.	4	1.3	0.380	
LIST TYPE x SORTING TECH x DELAY INT.	4	1.7	0.495	
ERROR	180	3.5		
WITHIN Ss VARIABLES				
TRIALS	1	26.9	36.571	
TRIALS x LIST TYPE	1	0.3	0.444	
TRIALS x SORT TECH	1	2.9	3.984	.05
TRIALS x LIST TYPE x SORTING TECH	1	0.1	0.179	
TRIALS x DELAY INT.	4	1.9	2.616	.05
TRIALS x LIST TYPE x DELAY INT.	4	0.6	0.802	
TRIALS x SORT TECH x DELAY INT.	4	0.3	0.458	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	1.1	1.454	
ERROR	180	0.7		

TABLE 17

ANALYSIS OF VARIANCE OF THE WORDS ADDED DURING t_3 NOT PREVIOUSLY RECALLED ON t_1 AND t_2 AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE AND DELAY INTERVAL

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	43.2	19.934	.001
SORT TECH (F vs C)	1	43.2	19.934	.001
LIST TYPE x SORTING TECH	1	3.1	1.440	
DELAY INTERVAL	4	4.8	2.233	
LIST TYPE x DELAY INT.	4	1.4	.666	
SORTING TECH x DELAY INT.	4	.5	.240	
LIST TYPE x SORTING TECH x DELAY INT.	4	1.5	.691	
ERROR	180	2.2		

TABLE 18

ANALYSIS OF VARIANCE OF THE NUMBER OF CLUSTERS USED DURING ACQUISITION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	124.3	32.529	.0001
SORT TECH (F vs C)	1	167.7	43.879	.0001
LIST TYPE x SORTING TECH	1	16.4	4.292	.05
DELAY INTERVAL	4	4.9	1.293	
LIST TYPE x DELAY INT.	4	10.6	2.765	
SORTING TECH x DELAY INT.	4	2.3	.607	
LIST TYPE x SORTING TECH x DELAY INT.	4	4.3	1.131	
ERROR	180	3.8		
WITHIN Ss VARIABLES				
TRIALS	1	297.6	159.148	.0001
TRIALS x LIST TYPE	1	19.8	10.591	.01
TRIALS x SORT TECH	1	7.6	4.045	.05
TRIALS x LIST TYPE x SORTING TECH	1	.3	.162	
TRIALS x DELAY INT.	4	1.6	.859	
TRIALS x LIST TYPE x DELAY INT.	4	4.3	2.325	
TRIALS x SORT TECH x DELAY INT.	4	3.3	1.768	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	3.4	1.830	
Error	180	1.9		

TABLE 19

ANALYSIS OF VARIANCE OF THE NUMBER OF CLUSTERS USED DURING RETENTION AS A FUNCTION OF LIST TYPE, SORTING TECHNIQUE, DELAY INTERVAL AND TRIALS

SOURCE	DF	MS	F	P
BETWEEN Ss VARIABLES				
SUBJECTS-	199			
LIST TYPE (R vs C)	1	95.1	20.825	.001
SORT TECH (F vs C)	1	165.1	36.174	.001
LIST TYPE x SORTING TECH	1	8.1	1.779	
DELAY INTERVAL	4	22.2	4.859	.01
LIST TYPE x DELAY INT.	4	15.9	3.482	
SORTING TECH x DELAY INT.	4	6.2	1.348	
LIST TYPE x SORTING TECH x DELAY INT.	4	4.4	0.962	
ERROR	180			
WITHIN Ss VARIABLES				
TRIALS	1	36.6	19.028	.01
TRIALS x LIST TYPE	1	11.2	5.834	.05
TRIALS x SORT TECH	1	6.5	3.380	
TRIALS x LIST TYPE x SORTING TECH	1	0.1	0.064	
TRIALS x DELAY INT.	4	14.5	7.542	.01
TRIALS x LIST TYPE x DELAY INT.	4	3.3	1.737	
TRIALS x SORT TECH x DELAY INT.	4	2.2	1.155	
TRIALS x LIST TYPE x SORT TECH x DELAY INT.	4	0.9	0.457	
ERROR	180			

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